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Agricultural Research Service

January 1992

# Agricultural Research



**It's the Berries**  
Cranberry story on page 4

## **From Asparagus to Mint— Research Makes It Better**

Corn, soybeans, wheat, rice, corn, soybeans, wheat, rice—this description of American agriculture is not only monotonous, it's also very incomplete.

All across this country, tucked away among the amber waves of grain, are thousands of acres of crops that some Americans may not even realize begin as crops—for example, 101,800 acres of peppermint and 33,700 acres of spearmint harvested in 1990.

Down the road and over the hill from the asparagus and cucumbers and yes, even the broccoli, the nation's farmers are also busy planting and tending and harvesting kiwi and pomegranates and even persimmons.

How economically important are these specialty crops? As examples, apricot production in the United States was valued at more than \$41 million in 1990; figs that year were a \$15 million market. Dried prunes from California were worth \$125 million.

The Agricultural Research Service's scientists work to solve the problems of these crops, just as they do for cattle or grain.

Cranberries (see story on p. 4) offer an example of research payoffs in specialty crops. A program peopled primarily with USDA staffers and dating to the 1930's has resulted in the release of several new cranberry varieties with qualities such as larger berries and higher yields. But these improved varieties bring other benefits, too. For example, Stevens cranberries are easily established and quick to fill in a bog—helping crowd out weeds and reducing the need for herbicides.

Another case in point: You'll probably never find yourself shopping at the local farmers' market for the choicest hops, unless you're planning to open a brewery. But the United States happens to be the second-largest hops-producer in the world, trailing only Germany. American farmers grow some 58 million pounds annually in Washington, Idaho, and Oregon.

American breweries now import about 16 million pounds of hops every year, so there is a market for the farmers' hops. To satisfy breweries' needs, ARS researchers have developed and released improved varieties such as Liberty, out last spring, and Mount Hood, a 1989 release.

And it isn't just the American breweries that are clamoring for greater quality and quantity in hops. Two Canadian operations and one in the Far East are reportedly interested in using Mount Hood in their brews—widening export opportunities for U.S. farmers.

Sometimes the emphasis is not so much on expanding what we have to sell as it is on reducing what we have to buy. Guayule, a shrub that grows wild in Texas and Mexico, is one crop that could help accomplish the latter objective.

Native to America, this drought-tolerant plant produces natural rubber, offering a homegrown substitute for a vital import. Some studies have suggested an impending worldwide

shortage of rubber—a shortage that could pinch the pocketbooks of American consumers as prices rise for rubber-reliant products such as radial tires.

ARS scientists have worked to breed guayule plants that yield more rubber per acre—about 1,000 pounds compared to the native plants' 500—and to fine-tune farming methods that help ensure a healthy crop.

The farm can be a contributor to a variety of industrial products, from plastics to printing ink. For example, U.S. industry currently uses about 40 million pounds of high-erucic-acid oil annually, importing the bulk of that total from Poland and Canada.

But U.S. farmers could grow a significant portion of the high-erucic oil needed, in the form of a crop called crambe. Crambe seed contains as much as 35 percent oil, nearly twice that of soybeans, and 55 to 60 percent of that oil is made up of erucic acid.

ARS scientists have taken a long, hard look at crambe. One result: At the agency's Peoria, Illinois, facility, recently renamed the National Center for Agricultural Utilization Research, researchers developed a product called Nylon 1313 from crambe-derived erucic oil.

Noted for its resistance to moisture, Nylon 1313 is ideal for the manufacture of truck airbrake lines, hydraulic and fuel lines, gears, tubing, and fasteners.

Researchers are pushing to meet farmers' needs as well as those of industry when it comes to crambe. ARS scientists have worked with specialists from Purdue University to develop a computer program to help farmers decide whether crambe is the crop for them.

Another intriguing newcomer is lesquerella, also an oilseed crop. Lesquerella is a truly American plant; every one of its known 69 species is native to North America.

Lesquerella seed contains about 25 percent oil, which can be extracted using standard oilseed processing. Lesquerella oil is very similar to castor oil, reportedly the most versatile vegetable oil now used in nonfood industrial products ranging from cosmetics to adhesive for artificial turf.

However, the U.S. castor oil supplies are entirely imported; lesquerella offers the opportunity to reduce that reliance on foreign suppliers. ARS researchers in Phoenix, Arizona, are part of a government/industry/university team seeking answers on how farmers can incorporate lesquerella into their operations.

A list of ARS research projects by commodity would probably include more than a few surprises for the average consumer who thinks of agriculture as all field crops and farm animals.

There are oranges that resist cold snaps, tastier catfish, muscadine grapes, thornless blackberries for painless picking, sweeter onions for more efficient pollination by honey bees, and strawberries that stay red even after freezing and thawing—all products of ARS research.

**Sandy Miller Hays**

Information Staff

Agricultural Research Service

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**Cover:** Rutgers University farm supervisor Richard DeStefano operates a ride-on water reel cranberry harvester at the Blueberry and Cranberry Research Center at Chatsworth, New Jersey.

Photo by Keith Weller. (K-4416-14)



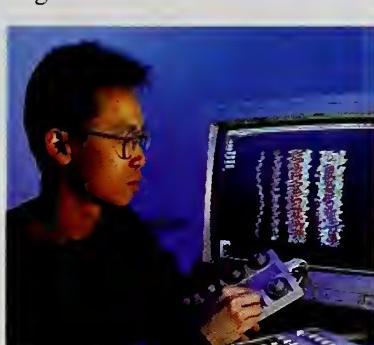
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# Cranking Up the Cranberry

## Can Cranberries Defend Themselves?

**I**t sits there on the Thanksgiving plate—a quivering, ruby-red jelled mold or a juicy, berried sauce. Just a couple of spoonfuls may be enough.

Cranberries are as traditional as the golden brown turkey or the kids dressed up like pilgrims for the Thanksgiving play.

No one seems to be able to determine whether or not the pilgrims served the little red berries at that first Thanksgiving dinner in 1621, but for sure the cranberry has since become part of the American heritage.

And ARS is helping to keep the tradition alive. In a joint research venture with Rutgers University's Blueberry and Cranberry Research Center, Allan W. Stretch is trying to find ways to help cranberry growers.

Stretch, a plant pathologist, heads the ARS part of the cooperative cranberry research effort with Rutgers at Chatsworth, New Jersey.

"Since Rutgers University breeds for new varieties here at Chatsworth, ARS concentrates its research effort on controlling diseases," Stretch says.

"Fruit-rotting fungi are cranberries' most serious disease problem," he says.

One of the fruit-rot problems targeted for research is black rot caused by the fungus *Allantophomopsis lycopodina*. Black rot can also be caused by two other fungi, *A. cytoporea* and *Strasseria geniculata*.

"Black rot infects fruit and spreads during water harvest, which is about 2 months after the last application of fungicide," Stretch explains. "This leaves the cranberries unprotected."

He is seeking alternatives—specifically, naturally occurring biocontrol agents.

"We've looked at the success others have had with natural bacterial, yeast, and fungal antagonists to control disease organisms on other fruit. We know there are similar biocontrol agents present in cranberries," Stretch says.

KEITH WELLER



ARS plant pathologist Allan Stretch (left) and associate professor Nicholi Vorsa of Rutgers' Blueberry and Cranberry Research Center examine the fruit resulting from crosses of Pilgrim and McFarlin cranberries. (K-4421-1)

And he has started work to find them. As in the case of stone fruit, Stretch hopes to find an agent that may trigger a defense reaction in the cranberry to fight the rot or one that might produce an antibiotic effective against fungal growth.

Cranberries are one of the specialty crops that will be affected if certain "minor-use pesticides" are lost to growers because manufacturers choose not to retain registration.

This situation stems from a 1988 law giving the Environmental Protection Agency authority to reassess the safety of thousands of chemicals already in use. These chemicals need to be re-registered, and manufacturers must

bear part of the registration fees and pay for studies to ascertain safety. This could prove too costly for the minor-use pesticides.

These are pesticides that are applied on small acreage crops—any crop other than wheat, corn, soybeans, sorghum, or cotton. Prospective loss of these pesticides makes Allan Stretch's research even more important to cranberry growers.

Potential loss of certain pesticides greatly concerns Nicholi Vorsa, too. Vorsa, a plant breeder/geneticist at Rutgers University, is trying to broaden the genetic base for cranberries in hopes of developing disease-resistant varieties.



"Six of the seven cranberry varieties released since the late 1800's were developed under USDA leadership. However, our genetic base is still too narrow," he says.

The industry is still largely based on selections from the wild. "ARS' search for biocontrol is one approach, but we also need a disease-resistant variety. Ideally, we'll couple that resistance with reliable productivity."

But crop breeding takes time. From cranberry seed to flower takes about 2 to 3 years. And selecting for yield can take up to 10 years or more.

Cranberries, says Vorsa, are a wetlands species. Because of legal restrictions on wetlands, it's difficult

for cranberry growers to expand their acreage. One way to meet increased demand—now that the red berries are no longer just a seasonal crop—is to plant more productive varieties.

"There's also an ever-growing market for cranberry juice," says Jack Crooks. Crooks, manager for agricultural research at Ocean Spray, says that about 90 percent of the cranberry crop goes for processing.

"We're supportive of the ARS and Rutgers University research. In fact, we'd really like to see ARS also involved in breeding."

Because cranberries are a specialty crop, there are only a few people doing genetics research. Vorsa, one of the few cranberry breeder/geneticist in the country, agrees that there is plenty of room for others to share in this work. "Since cranberries are grown in states having varied climates and problems, there is a need for additional breeding efforts."

"A new variety needs grower confidence," Crooks says. "That can only be gained through proven research, field tests, and having the proven varieties available to growers."

Headquartered in Lakeville-Middleboro, Massachusetts, Ocean Spray is a cooperative of grower-owners from five states and two Canadian provinces that produce cranberries, plus Florida grapefruit growers.

The cranberry, which got its name from its droopy blossom that looks like the head and beak of a crane, and the blueberry and Concord grape make up the three economically important fruits native to North America.

From 27,700 acres of cranberries grown in 1990, growers harvested about 169,000 tons of fruit, valued at over \$147 million. Massachusetts is the largest producer, followed by Wisconsin.

"Cranberries are remarkable because they grow in areas considered wastelands for other agricultural crops," Stretch says. "Unlike rich topsoil, a cranberry bog never wears out."

Most other agriculturally important plants can't exist in the acid soil of marshy bogs that are ideal for cranberry culture.

Planting a new crop of cranberries—perennial plants that produce an annual crop—is unlike planting any other crop. Growers simply cut the vines and spread them, a ton per acre, on land that has been leveled and covered with about 3 inches of coarse sand. Vines can then be hand-planted or disked into the sand where roots and top growth develop within about 2 weeks. The plant spreads by runners and then in the second year produces uprights—shoots that grow up from the runners. Fruit-bearing vines completely cover the ground by year 3.

Water is essential for a good cranberry crop. Cranberries need more water than any other agricultural crop.

In northern temperate regions, growers flood their crop in winter; an ice blanket keeps the vines from drying out and maintains a steadier temperature for the dormant crop. The flood, which also protects against frost, is

removed in spring but is reapplied to a depth of about 4 to 8 inches for harvest around October.

A harvesting machine that looks like an eggbeater dislodges the fruit from

KEITH WELLER



Cranberry half at right has black rot caused by a fungus. (K-4420-11)

## Exactly How Wet Is a Cranberry Bog?

To answer that question, ARS agricultural engineer Ronald E. Yoder, along with former ARS researcher Mary Hattendorf, set up a sophisticated weather station in a coastal Washington cranberry bog.

Looking something like a lunar lander, the station has an array of sensors mounted on a tripod that record air temperature, rainfall, humidity, and windspeed. Other probes measure the infrared temperature of the plant canopy, and soil moisture levels.

Data gathered in this study will be used to estimate the crop's water use and should help growers schedule irrigation according to crop needs, say the scientists.

In Washington, growers irrigate their bogs with sprinklers—about an inch of water per week. Although cranberries need a great deal of water, they don't thrive when the soil is too wet.

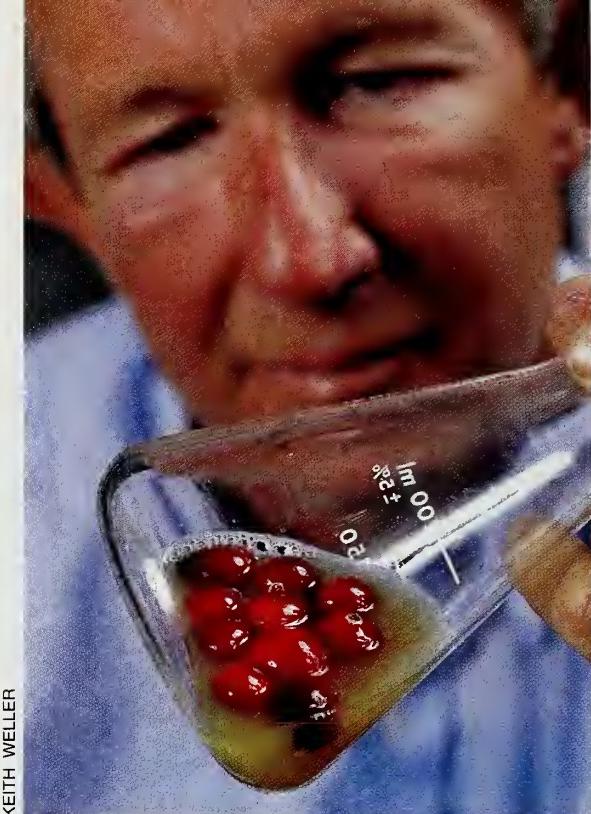
Cranberry producers would likely save money by reducing wasted water. And because the sprinkler water sometimes contains chemicals to control weeds, reduced water could curb chemical use as well. Cutting back on chemicals is particularly important in coastal wetland areas where wildlife abounds.

Agricultural scientist Joan Davenport, who is with Ocean Spray, participated in the research under a cooperative agreement with ARS.—By Julie Corliss, ARS.

KEITH WELLER



(K-4414-14)



KEITH WELLER

Damaged cranberries are dipped in a bacterial solution to see if it will inhibit fungi that cause black rot. (K-4420-2)

their stems. As the berries float on top of the water, a simple wooden boom pushes them to a loading area where conveyor belts carry them into waiting trucks. Within 24 hours, the fruit is cleaned and on its way to freezer storage.

Some growers dry-harvest with a piece of equipment that has what looks like a giant steel comb attached. The vines pass through the teeth which snaps the berries off. The berries are then transferred to burlap sacks for removal from the field.

Dry-harvested cranberries store better than wet-harvested ones. Refrigeration will keep berries for several months. In a fairly cool autumn, berries keep in common storage about 2 or 3 months. Not much storage time is needed for a crop that is processed in so many ways: sauce; juice cocktail; blended with apple, raspberry, blueberry, grape, and apricot juice; cranberry-orange relish; candied and spiced cranberries; and liqueurs.—By Doris Stanley, ARS.

Allan W. Stretch can be reached at USDA-ARS, Blueberry and Cranberry Research Center, Rutgers University, Penn State Forest Rd., Chatsworth, NJ 08019. Phone (609) 726-1590. ♦

# From Cattle Toxin to Anti-Cancer Drug

Locoweed, poisonous to livestock, contains a component that destroys malignancies.

**D**etective work that unmasked a plant toxin poisonous to beef cattle has helped medical science in its search for cancer-fighting weapons.

The toxin, swainsonine, can weaken and eventually kill not only cattle, but also horses, sheep, goats, and other animals that graze on the dozen or so rangeland plants commonly known as locoweeds, says ARS chemist Russell J. Molyneux at Albany, California.

But medical researchers, feeding the compound to laboratory mice, have discovered that swainsonine also stops growth of malignant tumors. Those scientists used tiny doses, unlikely to harm humans or animals.

Here's how this chemical from cattle-poisoning weeds in the American West ended up in cancer labs. Molyneux and colleague Lynn F. James at the ARS Poisonous Plants Laboratory in Logan, Utah, pinpointed swainsonine as the culprit in locoweed poisonings about 10 years ago. Their finding came about a year after Australian scientists discovered and named the toxin.

An article in *Science* by Molyneux and James noted swainsonine's effect on animal cells, first described by the Australians. Swainsonine soon captured the interest of medical researchers.

Among them was Kenneth Olden, head of a research team at Howard University Cancer Center in Washington, D.C. He realized that swainsonine might offer a promising new approach to fighting cancer.

Teams like Olden's went on to discover that small doses of swainsonine will indeed stop the spread of malignant tumors in laboratory mice. Swainsonine probably does that by boosting the number and activity of macrophages, helpful cells that fight cancer and other diseases.

Cancer research with swainsonine is continuing in labs in the United States, Canada, and Japan.

Olden's team first used toxin purified and supplied by Molyneux, who extracted it from locoweeds collected by James' staff in Logan. As interest in it grew among medical researchers, companies began making the compound; today, scientists can choose from natural or synthetic swainsonine.

Whatever fame locoweed may earn as the source of a potential cancer-fighting drug, it already has a reputation in cattle country. Animals that eat it may spook easily, withdraw from their companions, or wander aimlessly.

The plants get their name from the word "loco," Spanish for crazy. Poisoned animals may weaken, lose weight, and—if pregnant—abort, or bear young with birth defects.

Every part of the plant—blooms, stems, and leaves—harbors the toxin. Plants remain poisonous even when dead and dry.

Ranchers could protect their animals by herding them away from

locoweed-infested pastures and ranges when swainsonine levels climb. That's why Molyneux is tracking swings in the swainsonine content of American locoweeds such as the spotted species (*Astragalus lentiginosus*) or white locoweed (*Oxytropis sericea*).

Molyneux and the Logan team also want to find out how much swainsonine an animal normally converts into harmless compounds. "That's so we'll know—more precisely—how much locoweed animals can eat without danger," he says.

Swainsonine is an alkaloid, a class of chemicals that includes caffeine, cocaine, and strychnine. It may be habit-forming.

Poisoned animals, even if moved to safer pastures, will be more susceptible to swainsonine's effects if they ever again graze locoweed.—By Marcia Wood, ARS.

*Russell J. Molyneux is with USDA-ARS Plant Protection Research, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. Phone (510) 559-5812. ♦*

SCOTT BAUER



Chemist Russell Molyneux examines a locoweed plant while working with the structure of locoweed toxin, swainsonine, on the computer. (K-4269-4)

# Leaner Beef Benefits the Health Conscious

**T**oday's consumers are demanding lean beef, and ARS scientists across the nation are researching methods to help cattle producers meet those demands.

Current goals are to reduce outside carcass fat on meat to a minimum but keep 3 to 7 percent fat in the muscle to ensure good flavor.

Tommy L. Wheeler, a meat scientist at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) at Clay Center, Nebraska, is using a growth-promoting compound known as L-644,969 in studies of muscle growth in beef animals.

Small amounts of this growth promoter have been fed to cattle at MARC, Wheeler says.

"We're not exactly sure how it works, but this compound causes the animals to produce more muscle and less fat," he notes.

As an animal grows, muscle in its body is continually produced and broken down. Levels of natural substances called creatinine and three-methyl histidine in the urine of MARC test animals give researchers an indication of total muscle mass and how much muscle is being degraded each day.

"We look at these rates to find the point in the animal's growth cycle when major changes are occurring," says Wheeler.

The scientists also search the muscle of slaughtered cattle for signs of enzyme activity, specifically the enzyme responsible for the natural breakdown of muscle. Wheeler hopes to delineate the relationship between muscle growth, rate of muscle degradation, and enzyme activity.

"We hope this work will enable us to understand the mechanics of muscle buildup so that we might manipulate the system to make all cattle lean and muscular," says Wheeler.

Across the country at Beltsville, Maryland, animal scientist Christopher

KEITH WELLER



Food technologist Tommy Wheeler demonstrates the difference in the amount of fat trimmed from lean and fatter beef top rounds. (K-4285-3)

K. Reynolds is looking at the impact of diet on the metabolism of steers that have high levels of growth hormone.

In cooperative studies with Agriculture Canada scientist Helene Lapierre and others, steers were injected with a naturally occurring compound that causes an increase in the level of growth hormone in the animal's body.

The steers were then fed one of two levels of a feed concentrate diet. "I wanted to see if the response to elevated growth hormone would differ according to the level of nutrition received by the animal," explains Reynolds.

As a steer grows, its body transforms dietary energy into either protein or fat. Protein deposition—which primarily translates to lean meat—can be estimated from the amount of nitrogen the animal's body has retained from its diet.

Since scientists know the amount of nitrogen in the diet they've fed the

animal, they can calculate how much dietary nitrogen remains in the animal by checking its feces and urine to see how much nitrogen is excreted.

In turn, fat energy deposition is calculated as the difference between the total energy retention and energy retained as protein.

In Reynolds' study, boosting growth hormone levels did not affect total energy retention. But the steers' nitrogen retention doubled, which means protein deposition also doubled. And since total energy retention did not change, the amount of fat deposited decreased.

The researchers concluded from this study that injections of compounds to boost growth hormone levels in the animal will increase body protein gain regardless of whether the animal is being fed a high or low level of nutrition.

## Eschewing the Fat

The role of nutritional management in the production of lean beef is taking center stage as increasing attention is focused on finding various methods of producing low-fat meat.

"Nutrition has not been as much a factor in lean beef production in the past as it is now," says Lewis W. Smith, ARS National Program Leader for animal nutrition.

"In the past, producers tried to feed the cattle as much as possible to fatten the animals. Now they try to get growth without as much fat. It's more a question of what's not being done rather than what is done."

For example, producers are not putting cattle on high-energy feedlot diets as often as in the past but are using forage-based systems to reduce the amount of fat tissue deposited on the animals, notes Smith.

Finding the most efficient means of producing palatable lean beef in a range environment is one goal of ARS physiologist Bob Short's

JACK DYKINGA



Physiologist Bob Short measures the rib eye steak portion of a beef carcass. (K-4335-6)

research at Fort Keogh in Miles City, Montana. Joining Short in this work are Fort Keogh colleagues Elaine E. Grings, a range nutritionist; range ecologist Rod K. Heitschmidt; and plant physiologist Marshall R. Haferkamp.

"Since consumers want leaner beef, we need to find ways to speed

weight gain while minimizing the fat content," says Short.

Traditionally, producers use one of two feeding systems to raise cattle. After weaning, calves are generally sent either to a feedlot for finishing or to pastures where they graze before being sent to the feedlot.

Feeding grain to cattle, as is often the practice during the finishing stage, generally boosts the animal's rate of weight gain and fat deposition. Feeding more forage to finishing beef cattle decreases fat content in carcasses because high rates of gain and fat accumulation are more difficult on grasses.

"The problem is that range forage production is seasonal," Short explains. "High-quality forage may only be available for 2 months in some parts of the United States."

The Fort Keogh research program, dubbed the "lean meat" project, studies the effects of manipulating herd management practices and genetic variables to produce the leanest meat possible using range forage. Scientists will study eight variables, including the animal's genetic make-up, sex, age at weaning, and metabolic rate.

"We believe that most if not all of these eight variables can be manipulated to increase the efficiency of range forage systems," Short says. "Of those factors, the genetics of the animal and the feeding system are the two most important considerations."

Genetic traits have a tremendous impact on an animal's ability to produce lean meat. But within a genetic type, there are opportunities to alter body composition through management techniques, according to Samuel W. Coleman, an animal scientist at ARS' Forage and Livestock Research station at El Reno, Oklahoma.

Several years ago, scientists at the El Reno facility began studying growth rate patterns and body composition in Angus and Charolais steers.

"We wanted to see if body composition, altered by a period of restricted feeding, would influence an animal's ability to gain weight after it was restored to a normal diet," says Coleman.

Researchers found that for both Angus and Charolais, the size of the animal when it began eating a high-

JACK DYKINGA



Range nutritionist Elaine Grings prepares to collect cattle waste for analysis in studies to measure forage intake. (K-4336-5)



Technician Brooke Balsam prepares ground beef for fat analysis. (K-4332-5)

energy diet has a great influence on the resulting carcass composition.

For Angus steers, the age of the animal and its previous nutrition had little impact on the percentage of carcass fat if the steers were the same size when they started eating the high-energy feed concentrate. The animals that had weighed at least 800 pounds before changing diets were leaner.

"Results for Charolais steers were similar, but not as marked as those for the Angus," says Coleman.

That data led Coleman and Robert H. Gallavan, an animal physiologist, to their current project, determining how forage-based production affects the palatability and amount of meat produced.

In one study, a group of cattle ate a diet of 65 percent forage and 35 percent feed concentrates. A second group ate a diet of 85 percent feed concentrates and 15 percent forage.

Rates of gain were similar for the two groups until they reached 800 pounds. At that point, all the cattle were fed diets that were 85 percent feed concentrates.

Later, steers from each group were selected for slaughter according to body weight. "We wanted to know if the source of nutrition, independent of rate of gain, had an effect on body composition and organ size," says Coleman.

Of those slaughtered at 800 pounds, only 1 of 16 graded "choice," the quality preferred by most consumers. The carcasses were fairly lean and averaged 23 percent fat.

Seventy-five percent of the steers slaughtered 30 days later graded "choice," but were lean. When the animals were slaughtered at 1,000 pounds live weight, carcass fat was 29 percent; when they were slaughtered at 1,100 pounds, carcass fat was 32 percent.

Research at other locations has indicated that internal organs may enlarge when cattle are fed a forage diet. In the El Reno study, however, the weights of internal organs, such as the liver, rumen, and gastrointestinal tract, were unaffected.

Research data from the El Reno and Miles City studies are being relayed to a team of scientists in the Production

Systems Research Unit at MARC. Gary L. Bennett, leader of the MARC research unit, is working with animal scientists John W. Keele and Charles B. Williams to develop a computer model that can predict the body composition of slaughter-weight cattle.

A variety of diet combinations might be fed to cattle, each resulting in different growth patterns. The vast array of diets makes it nearly impossible to comprehensively study the implications of all feeding systems; the model could help fill in the blanks.

"The computer program evaluates the effect of patterns of growth on body composition at slaughter," says Bennett. "It will ultimately enable producers to look at different combinations of feeding systems to find which will produce the best beef."

The model takes into account animal growth rates at each phase of a feeding cycle, as well as the number of days at that rate. The model then calculates fat and nonfat composition of the animal at slaughter.

Researchers hope the model will eventually be able to predict characteristics such as yield and quality grades that affect the value of cattle, says Keele.

Currently, the model is loosely based on the size and fatness of a Hereford-Angus cross. Adjustments to consider breed, gender, and other factors will broaden the program's potential applications.

Before any of these methods results in more lean beef at the local grocery store meat counter, the methods must be passed along to and accepted by cattle producers and the beef marketing system.

"Still, you have to produce what the consumer wants or you might as well forget it," says Lewis Smith. By **Marcie Gerrietts, ARS**.

*To contact scientists mentioned in this article, write or telephone Marcie Gerrietts, 1815 North University St., Peoria, IL 61604. Phone (309) 685-4011. ♦*

# Good Fats Don't Diminish "Good" Cholesterol

If you're trying to eat less saturated fat, and you're opting for heart-healthy polyunsaturates instead, here's good news from ARS researchers.

A recent study at the Western Human Nutrition Research Center suggests that polyunsaturates—the kind found in corn oil margarine, for example—don't lower your levels of the good HDL cholesterol.

The finding comes from tests of 11 healthy middle-aged men who volunteered at the San Francisco center.

James M. Iacono, center director, and chemist Rita M. Dougherty conducted the 3-month study. They say that although their conclusion agrees with findings of some experts, it conflicts with others that have suggested that the highly touted polyunsaturates may reduce good cholesterol.

"Although there was a dip in HDL's at the midpoint in our study," Iacono notes, "HDL levels went back up by the end of the experiment."

HDL's, or high-density lipoproteins, have been linked with a lowered risk of arteriosclerosis (hardening of the arteries). The so-called bad cholesterol, or low-density lipoprotein, is blamed for higher risk of heart disease. HDL and LDL are typically measured in the comprehensive blood test usually included in yearly physical exams. A total cholesterol of 200 or less and an HDL level of above 45 are generally recommended.

For part of the San Francisco study, volunteers followed the eating guidelines recommended by the American Heart Association—fats were no more than 30 percent of the day's calories. Each type of fat—saturated, monounsaturated, and polyunsaturated—made up about 10 percent of the day's total calories. Then, to pinpoint any effects the polyunsaturates might have on HDL cholesterol, Iacono and Dougherty lowered levels of polys to 3.8 percent for part of the study.

SCOTT BAUER



Center director James Iacono discusses food weighing procedures with laboratory assistant Jan Thomson. (K-4275-2)

"Neither the 3.8 nor the 10 percent levels of polyunsaturates lowered HDL cholesterol for more than about 2 weeks," says Iacono. "In our new studies, we're looking for an explanation of why other researchers concluded that polyunsaturates lowered HDL's."

The ARS scientists relied on practical menus with typical foods that taste good and were easy to buy and prepare, yet were low in fat. Menus included, for instance, ham, turkey, meatloaf, baked fish, spaghetti, lasagna, or other familiar fare.

"Lowering the fat in your meals is often simply a matter of making easy substitutes at the supermarket or perhaps changing some of the ways you cook," says Dougherty. "You can cut fat calories if you trim visible fat off meat or choose lean meats and poultry. Or switch to low-fat or nonfat dairy products like skim milk or low-fat yogurt and reduced-fat sour cream."

"Instead of using butter for cooking or at the table," she adds, "choose polyunsaturated margarine like a vegetable-oil-based spread." —By Marcia Wood, ARS.

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SCOTT BAUER



Biological laboratory technician Elizabeth Denvir extracts samples for total lipid and fatty acid composition. (K-4276-3)



Biologist Judy Tolk checks leaf temperatures with an infrared thermometer at the rain-sheltered lysimeter site. (K-4426-1)

## Giant Scales Weigh Water

**Scientists check moisture use and loss by crops.**

To a rabbit scampering across it, it would look like any ordinary wheat field in the Great Plains. The innocent rabbit would never know that it had just had its weight recorded by federal scientists.

Hidden in the middle of the field are four massive ground-level soil tanks poised on underground scales. Called weighing lysimeters, these 50-ton instruments are definitely not designed to weigh rabbits, although they can distinguish weight changes as slight as a pound.

Instead, the USDA Agricultural Research Service uses them to monitor the weight losses caused when water either evaporates from the soil or plant leaves or is transpired by plants. The rate of evapotranspiration is critical in an area this dry—so dry that, according to Bobby A. Stewart, not a month goes by, on average, that more water

wouldn't evaporate from a standing water surface than is gained from rainfall. Stewart is director of the ARS Conservation and Production Research Laboratory in Bushland, Texas.

The Bushland lab has four weighing lysimeters, each in the middle of an 11-acre field. Each lysimeter is really "a box of soil on a scale," says Arland D. Schneider, an ARS engineer.

Each box is 10 feet by 10 feet by 7.8 feet deep. The support staff at the lab enclosed the 780-cubic-foot blocks of soil in steel tanks and hired contractors to lift them onto the scales. The crane operator didn't believe Schneider when he told him each would weigh 100,000 pounds—until he started lifting one.

Visitors are amazed when Schneider opens a trap door and invites them to climb down 12 feet beneath the field with him. In a room deliberately painted white and brightly lit to make it

"user-friendly," observers can readily see that the soil tank plots sit on scales.

Schneider explains that the goal of the Bushland research team is not a lysimeter in every wheat field. "The whole purpose of this continual monitoring is to see if we can improve evapotranspiration predictions from weather data, rather than having to measure changes as they take place," Schneider says.

Since evapotranspiration is a measure of a crop's water use, the ability to predict its rate is necessary for farmers in deciding when to turn irrigation pumps on and for researchers using computers to simulate crop growth.

Schneider is a member of a research team that includes agricultural engineer Terry A. Howell, soil scientists Jean L. Steiner and Steve R. Evett, and biologist Judy A. Tolk.

The team has grown wheat, corn, and grain sorghum on the lysimeters in the past 3 years. "On the average, the seasonal water use was no greater than expected," Schneider says. "But I was surprised by the tremendous variability in water use from day to day."

There was also more loss of water to drainage than expected, he says, as he describes the 16 tubes that drain water from each lysimeter.

In cooperation with Sam J. Smith, an ARS water quality researcher in Durant, Oklahoma, the researchers analyze the waste water for fertilizer leaching. They have found some leaching in the loam soil typical of several million irrigated acres in the Bushland-Amarillo area of the west Texas High Plains.

Schneider explains that every day at 5 minutes after midnight, the computer at the lab's headquarters a mile away phones underground computers in the wheat field to collect data. The data is ready to be processed in the morning when technicians arrive at work.

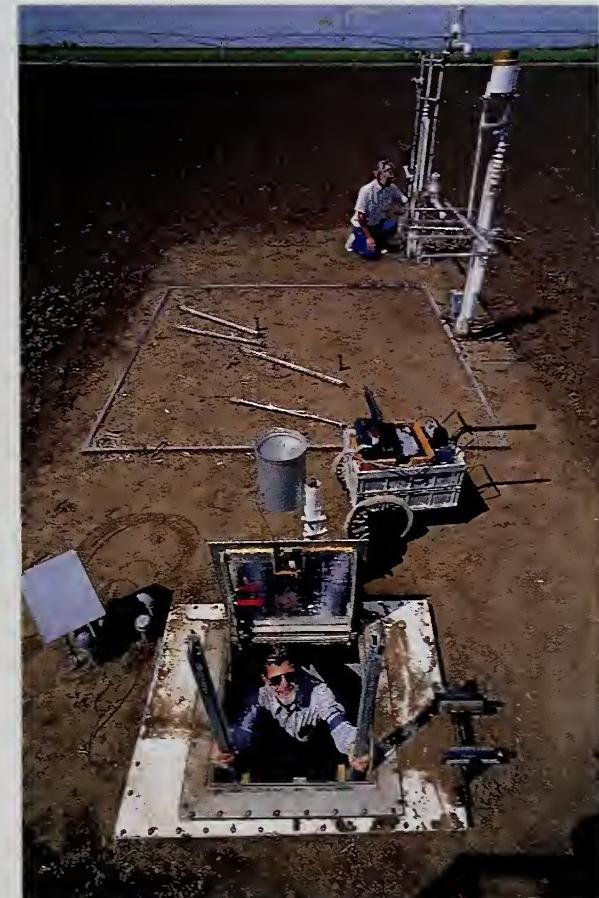
Schneider points out some of the key weather instruments located at

each site: an anemometer to measure windspeed and wet and dry bulb thermometers for calculating relative humidity. "There are also a number of sensors to measure how much sunlight is reflected upward by plants and how much is getting through to heat the soil," he says. Other instruments measure soil water content, soil temperature, and the transfer of heat in and out of the soil.

"We also have a fully equipped weather station located nearby that collects data such as windspeed and direction, temperature, and evaporation," he says.

"When we moved each 780 cubic feet of soil, we moved it as one block, intact," Schneider says, "rather than excavating it layer by layer and filling it in reverse. The actual process involved using hydraulic jacks to force the temporarily bottomless lysimeter tank into the ground. Once it reached ground level, workers placed steel pipes through the soil below the tank to

JACK DYKINGA



Arland Schneider climbs from the underground lysimeter utility room while soil scientist Steve Evett conducts bare soil evaporation experiments. (K4425-1)

JACK DYKINGA



Twelve feet beneath the field, engineer Arland Schneider checks equipment used to weigh one of the large lysimeters. (K-4425-14)

form a temporary bottom. A pair of cranes lifted the tank and its 50-ton load out of the hole and then a permanent bottom was welded in place.

"This method lets us avoid errors caused by disturbing the soil," he says. "Actually, we didn't have a choice because this soil has a natural caliche (calcium-carbonate) layer 3 to 5 feet deep that can't be reconstructed anymore than a rock could be smashed and reassembled."

"We've also placed the plots in the middle of large fields so that there are 125 yards of crop between the lysimeter plants and the field edges in any direction," he says. "It's vital to place the lysimeter far enough into a field so that plants on its surface respond exactly like those growing in the middle of a farmer's field."

A large mechanical sprinkler irrigator can water any one of the four fields or two fields simultaneously, to compare irrigated and nonirrigated farming. For example, Steiner has tested sorghum in high and low levels of winter wheat residue, produced by growing the wheat with and without irrigation. Steiner plans to do more research to compare the effects of crop residue left on the surface by different methods of tillage.

Evett is using the weighing lysimeters to monitor evaporation from bare soil. "With our evaporation potential higher than our rainfall potential, we have to depend on rainwater stored in soil. Great Plains farmers usually leave dryland fields bare or fallow for 11 months between crops to give the soil a chance to store moisture," he says. Rain is anathema to scientists who want to control the amount of

water an outdoor plant gets. The solution is a moving shelter. Rainfall activates a specially designed building, causing it to automatically move over and close its doors around the 48 small lysimeters at the site.

Each of the lysimeters is 30 by 40 inches by 7.8 feet deep, containing a 65 cubic feet block of undisturbed soil.

Twenty minutes after the rain stops, the doors open and the rain shelter retreats, allowing normal conditions again.

Twenty-four of the small lysimeters contain soil cores collected at Garden City, Kansas—250 miles north of Amarillo. It took a caravan of five 18-wheelers to haul the soil, Schneider says. "This silty loam soil is what you find in a large area around Garden City," Schneider says.

Twelve other lysimeters are filled with a fine sandy loam soil from Big Spring, Texas, which is 250 miles south of Bushland. The final 12 lysimeters have the loam collected at the Bushland lab.

"You can walk just 40 feet here and pass the three major soil types you'd normally have to take a 500-mile-long trek from Texas to Kansas to see," Schneider says. "This gives us a rare opportunity to accurately extrapolate our results to a wider region. We can also do drought experiments on three different soils under the same climate conditions."

These lysimeters are weighed periodically by being lifted slightly by a crane supported by the rain shelter building. The crane is suspended within the building to cut wind-caused vibrations during weighing.

"We're just getting started with these lysimeters. Last winter and spring, we grew winter wheat. This summer we're studying four varieties of grain sorghum to see how they are affected by late-season drought in these soils," he says.

The rain shelter and lysimeters provide a unique combination. They are considered among the best of this type of facility in the world. ARS also conducts soil and water research with lysimeters at Fresno, California, Coshocton, Ohio, and Temple, Texas.—By **Don Comis**, ARS.

*Bobby A. Stewart, Arland D. Schneider, and Jean L. Steiner are at the USDA-ARS Conservation and Production Research Laboratory, P.O. Drawer 10, Bushland, TX 79012. Phone (806) 356-5732. ♦*

JACK DYKINGA



Under the movable rain shelter, biologist Judy Tolk uses a hoist to lift and weigh one of the small lysimeters. (K-4429-1)

# Researchers Mind the Mint

**F**rom juleps to grasshopper pie, toothpaste to antacids—mint sparkles the flavor of our foods and our pharmacy items.

Mint's distinct, refreshing taste comes from volatile oils produced in tiny sacs in the leaves and stems of various *Mentha* species—*Mentha piperita*, or peppermint, being one of the most common.

Surprisingly, there are close to 500 different accessions—including chocolate mint, pineapple mint, eau de cologne mint, to name a few—at the National Clonal Germplasm Repository's collection of *Mentha* and *Pycnanthemum* (mountain mint).

Located in the heart of mint-growing country—Oregon's verdant Willamette Valley—the fragrant assemblage of mints is the largest in this country, and one of the most diverse worldwide, says Henrietta L. Chambers, who oversees the collection.

The mints are one of many different crops, including pears, most berries, hazelnuts, and hops, housed at the Corvallis, Oregon, repository.

The repository is one in a network of 30 ARS-managed gene banks that preserve economically important crops and their wild relatives.

These gene banks assure plant geneticists a ready source of material for breeding new crops to resist environmental stresses, such as insect pests or unfavorable weather. Another important function is to save rare species related to cultivated plants that might otherwise be lost due to livestock grazing and construction.

In the case of mint, however, several unusual applications of the collection have cropped up.

For instance, last year the National Cancer Institute in Bethesda, Maryland, requested samples of several *Pycnanthemum* species to screen them for anti-cancer or anti-AIDS properties. Recently, however, word came back that the findings were negative. "We

MICHAEL THOMPSON



Horticulturist Henrietta Chambers plots the distribution of New Zealand mint. (K-4424-5)

were a bit disappointed, but we were glad to have used the collection in such a way," says Chambers.

Yet *Pycnanthemum* species may offer hope for other, less serious but still troublesome problems, according to James Duke, a botanist with the ARS Germplasm Resources Laboratory in Beltsville, Maryland. Mountain mint, pennyroyals and *Hedeoma pulegioides*, and corn mint, all contain high levels of pulegone, a compound that repels fleas, ticks, and mosquitoes.

Certain ticks carry organisms responsible for Lyme disease and Rocky Mountain spotted fever, Duke points out.

Other compounds in *Pycnanthemum* and *Mentha*, namely menthol and menthone, may help alleviate decompression syndrome and altitude sickness, problems that plague scuba divers and mountain climbers. A 1986 study showed that the compounds help prevent the cause of both ailments—the aggregation of blood components called platelets.

Mints might help solve economic as well as medical problems. Because it's a relatively high-value crop (the oil is worth between \$15 and \$25 a pound), ARS scientists consider mint a possible alternative crop for Bolivian peasants who farm coca in the Andean foothills.

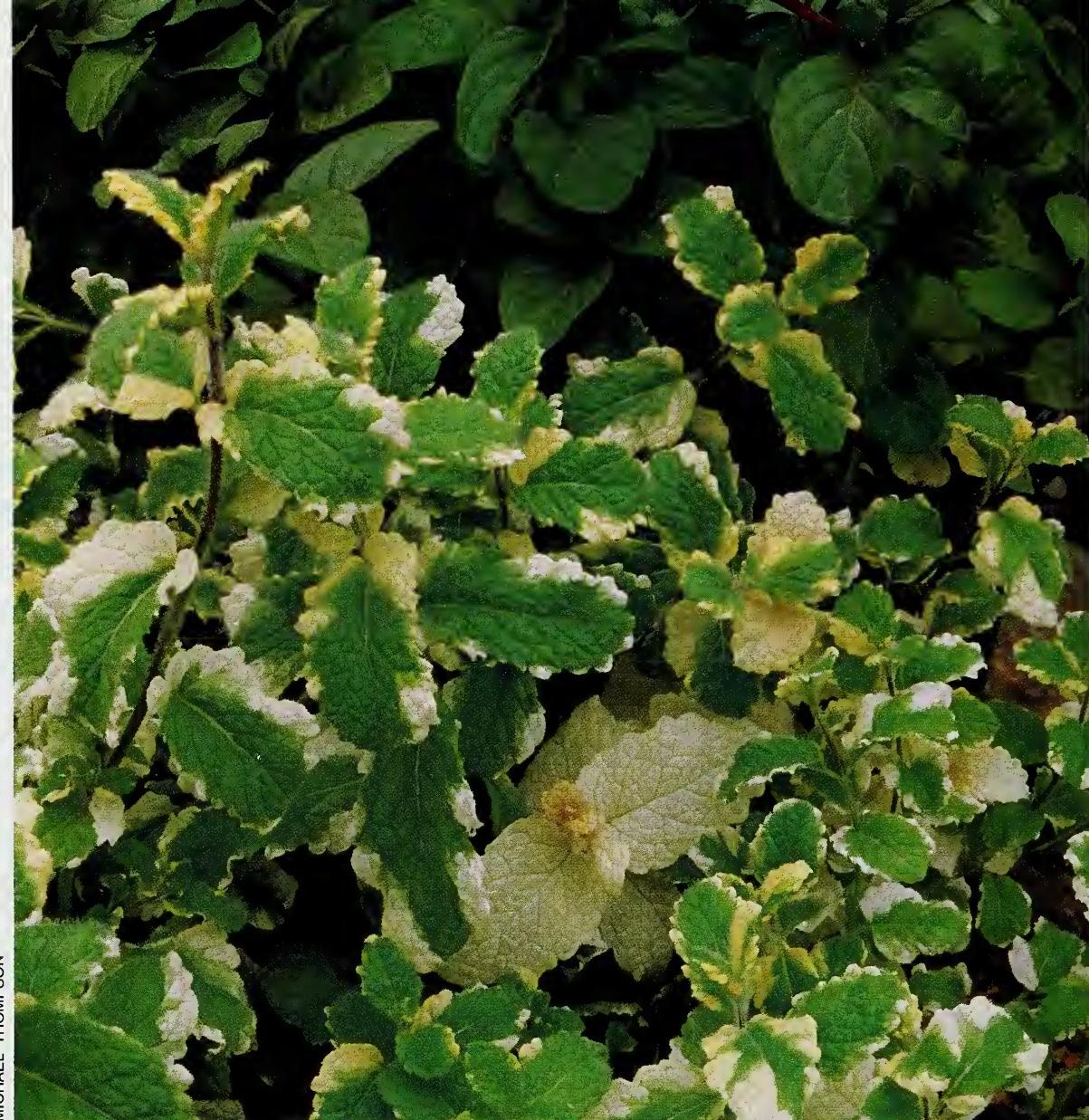
In 1990, Chambers sent six mint accessions to a scientist at an agriculture development program affiliated with San Simon University in Cochabamba, Bolivia. Included was a genotype grown in Brazil that could feasibly also thrive in Bolivia. For now, however, it's still too early to comment on mint's success, says George A. White of ARS' National Germplasm Resources Laboratory, who supervises international germplasm distribution.

No matter where it's grown, mint shows up in cuisines throughout the world. A fresh mint sprig makes an attractive garnish on any plate. The fragrant herb also appears often in Indian, Thai, and other Middle Eastern dishes, either sautéed with meats or minced fresh in salads.

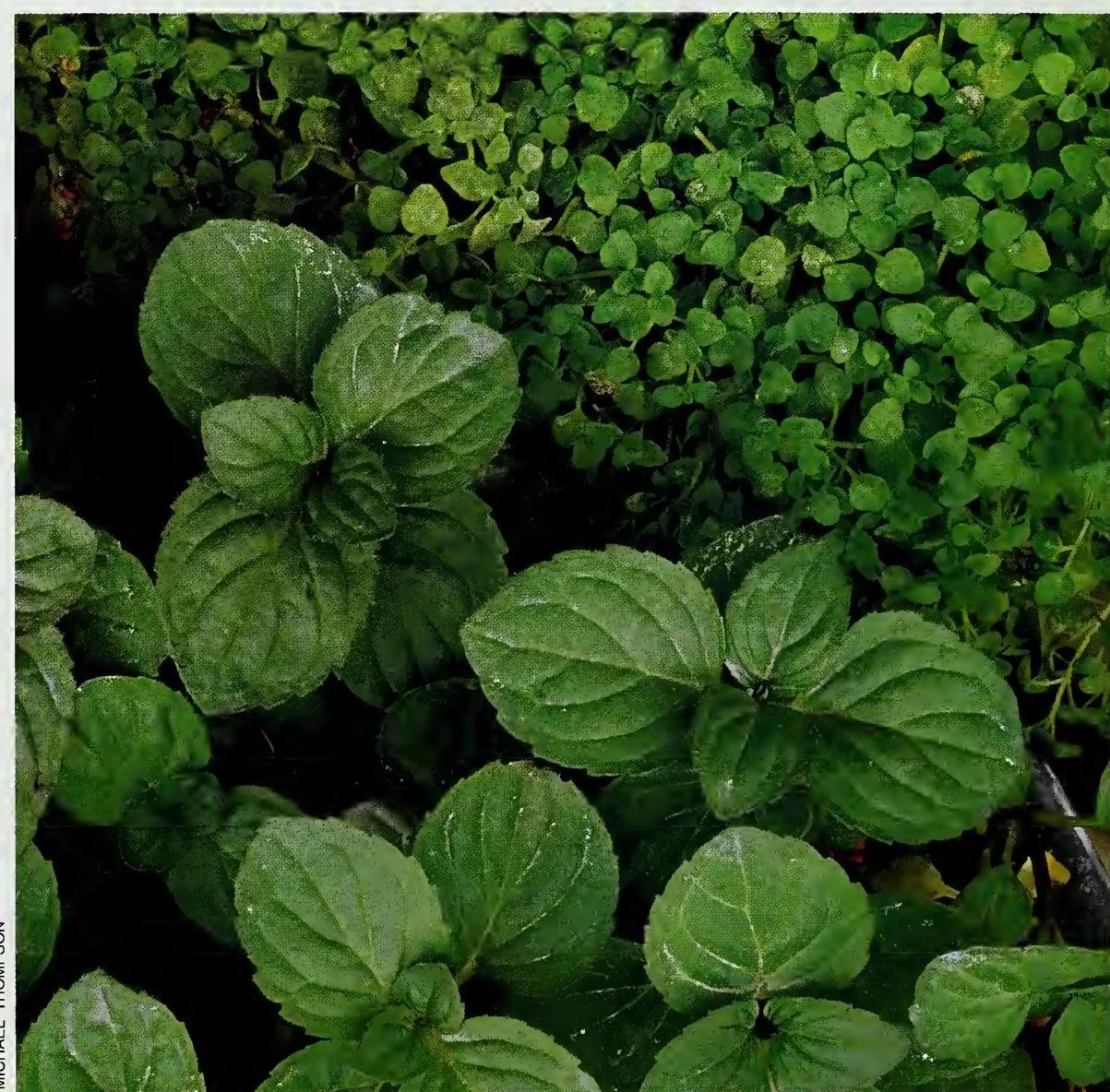
Mint oils, however, are much more widely used, particularly in America and European countries. Probably the most familiar uses of mint flavorings are in chewing gum and toothpaste. But it's found throughout the medicine chest—in mouthwash, antacids, even shaving cream. Cough drops sometimes contain one of mint's chief volatile oils, menthol.

Many noncaffeinated or herbal tea blends include dried peppermint or spearmint leaves. And the Oregon Mint Snuff Co. sells dried mint leaves as a substitute for chewing tobacco. The all-mint chew is billed as a nonharmful alternative to smokeless tobacco, the use of which has been linked with oral cancer.

Mints may have a place in your garden as well as in your home—some are attractive ornamentals. For example, the low-growing Corsican mint,



An assortment from the mint collection: (top to bottom) solid-green orange mint, variegated pineapple mint, fine-leaved Corsican mint, and peppermint. (K-4424-4) (K-4424-2)



MICHAEL THOMPSON

native to that Mediterranean island and others, makes a soft, mosslike carpet that will spread to fill in cracks between a rock path.

"When you walk on it, you'll notice a nice, fresh mint aroma," says Chambers. While the plants may die back over the winter in colder climates, they revive in spring and aren't bothered by foot traffic.

Pineapple mint, sporting light green leaves with white edges, also makes a nice ornamental, as does a variegated (green and white) peppermint. And there is the round-leaved *Mentha sauvoleens*, or apple mint, which, according to Chambers, really does have an apple fragrance.

For a citruslike scent, there's an orange mint. And chocolate mint is a nursery favorite, according to Bob Hornback, manager of the Ya-Ka-Ama Nursery in Forestville, California, which retails over 15 to 20 different mint varieties.

Hornback admits that the chocolate smell is "more in the imagination of the beholder," adding that he thinks of chocolate peppermint patties.

The plant's stems are a deep chocolate brown color, rather than the reddish brown of most other peppermints, says Chambers, who herself conjures up visions of chocolate mint Girl Scout cookies.

What about the eau de cologne mint? "It has a smell reminiscent of lavender," says Chambers.

Each variety, along with many other accessions, grows in 6-inch pots in a screenhouse. The screenhouse excludes insects like whiteflies that may transmit viruses or bees that may pollinate the mint flowers.

While most of the accessions originated in Europe, others come from elsewhere around the globe—Japan, Morocco, Pakistan, and Russia. Chambers hopes to visit New Zealand and Australia to collect mints native to those countries.

"There are wild mints growing in Australian grasslands we'd especially like to have—there's heavy livestock grazing in those areas that could wipe out certain species," she says.

The *Mentha* genus, Chambers points out, is just one among 180 different genera in the broader mint

## A pound of mint oil can flavor 45,000 sticks of gum.

family, Labiateae. Other well-known mint family members include many culinary herbs such as basil, marjoram, and oregano, as well as catnip and lavender.

Salient features that identify mint, notes Chambers, are plants with a distinctive (not always pleasant) scent, and leaves that grow in pairs opposite each other on a square stem.

Most mints display spikes of white or pale lavender flowers with tiny purple spots. Chambers uses these flowers in the further evaluation of the collection—counting the chromosomes in cells that develop into pollen.

She first pickles, or preserves, the tiny mint flower buds in a mixture of chloroform, alcohol, and acetic acid. The solution pulls water from the plant's cells but leaves them otherwise intact.

Next she squashes the flower's anthers—where pollen formation takes place—and stains them for viewing under the microscope. She can then observe meiosis, the cell division that gives rise to the pollen, the plant's male sex cells. Because they will later fuse with the female sex cell, or egg, the pollen grains (like the egg) contain only half the chromosome set and are thus easier to count than other cells, which contain the double set. Mints have

between 18 and 144 chromosomes, says Chambers.

Some mints have three, rather than two sets of chromosomes. These triploid plants are sterile, because the third chromosome set can't pair properly. Mint farmers require sterile plants, because mints, like all clonally propagated plants, produce seeds that are genetically different from the original plant. Farmers can't have these other mints contaminating their stands, since mint processors demand pure oil from a single genotype.

Peppermint, Chambers points out, is actually a hybrid species—an ancient cross between spearmint (*M. spicata*) and *M. aquatica*, a broadleafed mint that doesn't have an especially good fragrance.

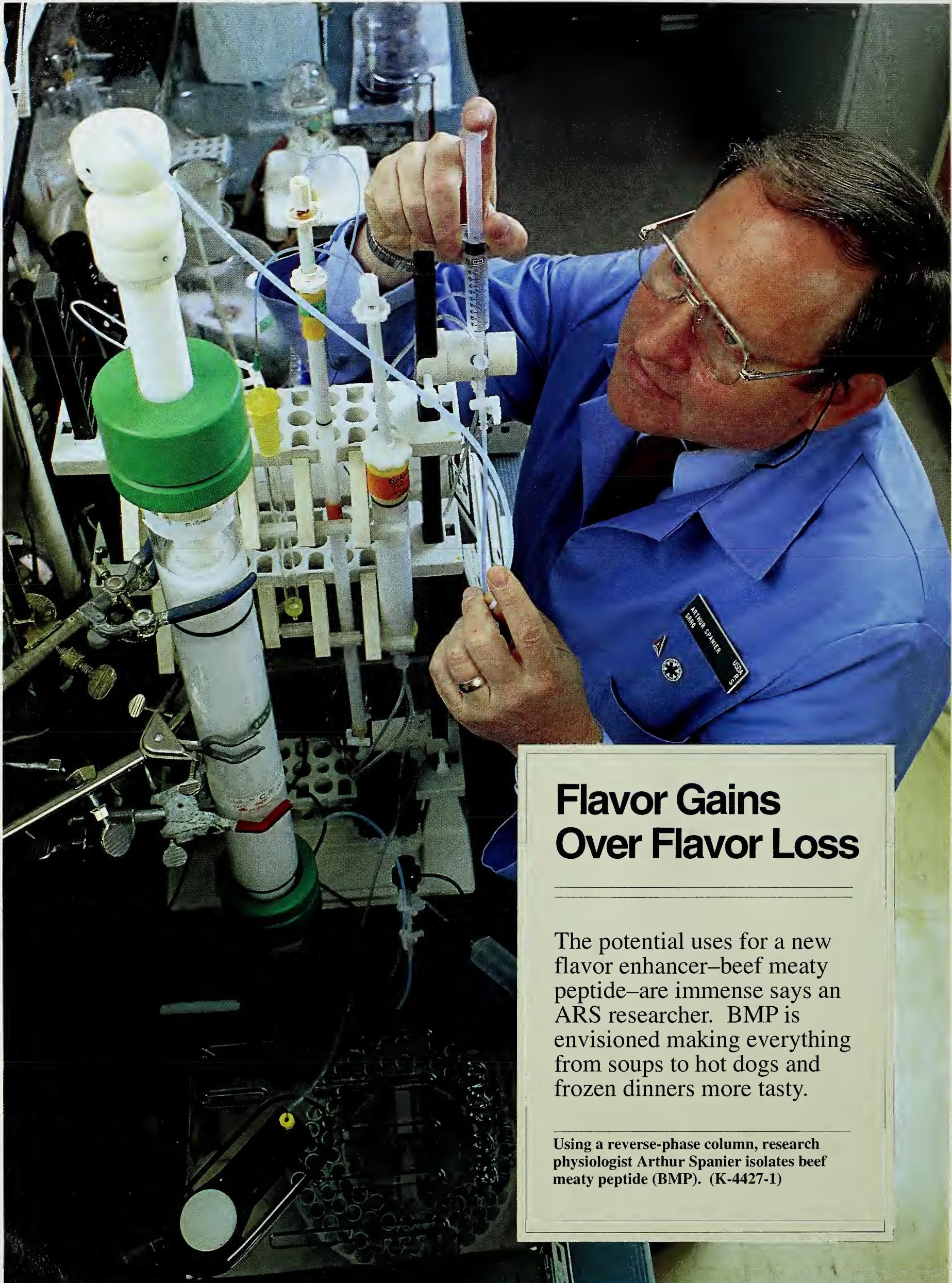
The most popular northwestern cultivars are Mitcham peppermints, named after a town near London, where they were first collected. Native spearmint and Scotch spearmint are also grown.

Mint harvesting begins in mid to late summer, when the plants are 2-3 feet tall. Farmers cut plants close to the ground, leaving them in windrows—heaps of hay left in the field to dry for a few days. Afterwards, the mint is steam-distilled to extract the oil.

Oregon leads the nation in mint oil production, followed by Washington and Idaho. Smaller amounts grow in Montana, Michigan, Indiana, South Dakota, and Wisconsin.

Growers sell the oil by the barrel to various companies, such as Wrigley's and Palmolive, whose scientists then blend different batches of oil to achieve a desired flavor or scent. According to the Oregon Mint Commission, a pound of mint oil can flavor 45,000 sticks of gum.—By Julie Corliss, ARS.

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## Flavor Gains Over Flavor Loss

The potential uses for a new flavor enhancer—beef meaty peptide—are immense says an ARS researcher. BMP is envisioned making everything from soups to hot dogs and frozen dinners more tasty.

Using a reverse-phase column, research physiologist Arthur Spanier isolates beef meaty peptide (BMP). (K-4427-1)

If that sizzling T-bone steak you're grilling doesn't quite live up to its mouthwatering promise once it's on your plate, you might want to enhance its flavor by sprinkling it with a variety of artificial or synthetic flavorings.

But Agricultural Research Service scientists have a natural flavor enhancer that could make your steak taste beefier. The flavor enhancer is also a source of nutritional protein.

Arthur M. Spanier, an animal physiologist at ARS' Southern Regional Research Center in New Orleans, Louisiana, found this flavor enhancer in beef and calls it BMP for beefy meaty peptide.

Naturally found in beef, BMP consists of eight linked amino acids produced during the aging of meat after slaughter.

"Muscle is mostly protein in nature," Spanier explains. "When the animal is slaughtered, proteins in muscle tissue are naturally broken down by enzymes into smaller proteins called peptides. This is part of meat aging and tenderization."

According to Spanier, individual amino acids have different tastes—some sweet, some sour, and some bitter.

"The flavor of BMP is quite specific," he says. "If one or more amino acid links are removed from the chain, its beefy flavor is lost and it develops a bitter or sour taste."

Some of BMP's links can be lost through continued enzyme activity. Spanier contends this is a cause of the decrease in beefy flavor of leftovers and other precooked meats.

The main flavor enhancer now used in foods is monosodium glutamate (MSG). This compound can be derived from several animals and plants, but comes primarily from microbial fermentations. "All MSG does is stimulate more taste bud endings," Spanier says, "while BMP provides a specific beefy taste."

"However, large-scale production of BMP from beef, perhaps as a potential

flavor enhancer, will require that scientists find the protein from which BMP originated."

Once that crucial protein has been identified, it may be possible to breed cattle to produce cuts with a richer beef flavor. Information on the origin of BMP could also help the meat industry find slaughter methods that stimulate its production.

Understanding the structure and formation of BMP could also allow scientists to genetically engineer the protein into easily grown yeast or bacteria for more economical large-scale production, Spanier adds.

The potential uses for BMP are immense, he says. It could be used to make a beefy stock. It could be sprinkled—like salt and pepper—onto a less flavorful cut to make it taste like an expensive one. Or it might even be added to precooked foods such as hot dogs and frozen dinners.

### Flavor Loss

Meanwhile, other researchers at the New Orleans lab have devised a way to halt meat-flavor deterioration.

A derivative of chitin, the fibrous portion of shells from crab, shrimp, lobster, and crawfish, is used to bind the iron that causes fats to oxidize. This oxidation is the cause of off-flavors in meat, says chemist Allen J. St. Angelo.

The derivative used in the ARS-patented technique is called N-carboxymethylchitosan (NCMC). NCMC is a natural water-soluble carbohydrate that has no known allergic or toxic side effects. It comes from chitosan, a gum made from chitin in waste crustacean shells.

Chitosan is presently used by the food industry to clear cloudiness in production and as an ingredient in cosmetic creams and toothpaste.

Although NCMC binds iron in meat, researchers think the iron is still available for nutrition, says John R. Vercel-

lotti, also a chemist and co-inventor of the technique with St. Angelo.

"We were looking at a large number of food gums that have properties of inhibiting fat oxidation," St. Angelo says.

"What we had to do was find one that had a chemical claw that would grasp iron effectively in meat, but not have a flavor itself." More than 25 compounds were tested.

Vercellotti says it is essential to prevent fat oxidation because once the process begins, there is no way to stop flavor deterioration and restore lost quality.

The ARS patent has drawn interest from industry for uses when meat is precooked and served later, such as in institutional, airline, or delicatessen foods as well as fast-food outlets.

It could also be used in frozen dinners and dehydrated soups, St. Angelo says. However, the technique must receive Food and Drug Administration approval before it is commercialized.

### Potato Starch Gel

While beef flavor is important, so are concerns with beef's cooking yields and fat content. Bradford W. Berry, a food technologist at the ARS Meat Science Research Laboratory in Beltsville, hopes to boost the cooking yield—the amount available to eat after cooking—and lower the fat content with one simple ingredient: potato starch gel.

When added to ground beef, potato starch gel absorbs water. In addition, the swollen starch gel compresses meat tissue. This makes the meat product more tender, says Berry.

The additive also tends to accelerate internal heating in ground beef patties, thus melting fat.

"It forms channels where fat escapes from the patty during cooking before the burger's surface sears or gets crusty and locks in the fat," he explains.

"With this additive, the fat is able to escape because it isn't running into any barriers."

Berry developed the additive to satisfy consumer and industry demands for a tender, low-fat burger with a high cooking yield. The additive increases cooking yields by about 6 percent.

If lean ground beef is mixed with the additive, the fat content of the resulting cooked burger is about 4.5 percent less than in a cooked all-beef burger, Berry says.

But while developments to improve flavor, nutrition, and cooking yield may look great in the laboratory, the ultimate test will come in the real world.

Since the final judge of the success of ARS' meat quality research is the consumer, a special group of consumers is an integral part of meat research at the agency's Roman L. Hruska U.S. Meat Animal Research Center (MARC) at Clay Center, Nebraska.

Eight people from nearby communities are part of a sensory panel at MARC to test the palatability of meat produced in various beef research projects. The panel meets about three times a week to evaluate attributes such as the tenderness and flavor of different cuts of meat.

"We feel that it's a very important component of our research here," says Mohammad Koohmaraie, who heads the center's Meat Research Unit.

Prospective panelists are carefully screened to determine their abilities to detect differences in meat samples. Once on board, the panelists use a scoring system to rate beef's juiciness, ease of fragmentation, amount of connective tissue, overall tenderness, flavor intensity, and off-flavor. Current panel members have served from 3 to 11 years.

"We don't tell them in advance what they'll sample," says L. Kay Theer, a food technologist who coordinates the panel. "They find out what the scientists are testing after it's all over."



Physiologist Arthur Spanier (left) and chemist John Bland compare the structure to flavor relationship of peptides. (K-4427-8)

Results of the taste tests are revealed after the research project is completed, she says.

For example, the panel was instrumental in research aimed at speeding up the tenderization process for beef. Koohmaraie, a physiologist at MARC, discovered an enzyme system that breaks down muscle fiber with the help of calcium chloride, cutting tenderization from 2 weeks to just 24 hours. Calcium chloride is an approved food additive.

"Calcium is a natural component of beef, but there is not enough present naturally to produce the level of tenderness that consumers desire," Koohmaraie says. "Injecting cuts of beef with calcium boosts enzyme activity and accelerates the tenderization process."

Each ARS research project is aimed at providing consumers with more ways to take advantage of beef's nutritional value. Beef is a major source of protein, iron, zinc, and vitamin B12, says Jacqueline Dupont, ARS National Program Leader for human nutrition.

"Such a rich nutrient source as beef—a food that many people enjoy—should be included in the diet," says Dupont. "The dietary guidelines for Americans recommend at least two 3-ounce servings of meat, poultry, fish,

dried beans, or eggs per day. Lean beef is a good choice."

Beef's vitamin and mineral benefits help decrease the risk of anemia in children, says Dupont. The concentration of nutrients in beef makes it possible for children to obtain essential dietary requirements without having to consume a large amount of food.

"Our lab in Boston has also found that vitamin B12 is very important in the diet of the elderly, and beef is one of the best sources for this vitamin," Dupont says. "We're also studying how meat protein and fat may enhance the body's ability to absorb iron from other foods."

She says advances in genetics, breeding, and cattle management have greatly reduced fat content, making beef as nutritionally attractive as many other foods.—By Bruce Kinzel, ARS.

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*Bradford W. Berry is at the USDA-ARS Meat Science Research Unit, Beltsville, MD 20705. Phone (301) 344-1994. Mohammad Koohmaraie and L. Kay Theer are at the USDA-ARS Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE 69933. Phone (402) 762-4100. ♦*

# Keeping Your Carcass Clean

**J**ames S. Dickson, a microbiologist at the Roman L. Hruska Meat Animal Research Center (MARC), and Maynard E. Anderson, an agricultural engineer at Columbia, Missouri, have teamed up to help ensure that the public is getting the cleanest meat possible.

The external carcass surface can become contaminated during slaughter by dirt and mud. Removing hide and hooves and immediately washing and sanitizing the carcass will stop the bacterial threat, the researchers say.

Anderson and several colleagues have invented and patented an automatic high-pressure carcass washer that removes most of the foodborne pathogens found on the carcass surface. "A good washing will remove about 90 percent of the bacteria on a carcass," says Anderson.

In the past, the packing industry has used a weak chlorine solution to kill harmful organisms. Currently, natural organic acids are used for sanitation.

ARS researchers have studied the effectiveness of the organic acids on carcasses contaminated with bacteria including *Enterobacteriaceae*, *Escherichia coli*, and *Salmonella typhimurium*.

Lactic and acetic acids were tested, as were combinations of lactic, acetic, ascorbic, and citric acids. The scientists changed the temperatures and combinations of acid in search of the most effective treatments.

They found that, in general, increasing either the concentration or temperature of the acids resulted in a greater reduction of bacterial contamination.

At all temperatures, lactic acid was most effective against *Salmonella* bacteria. Acetic and lactic acids, as well as one of the acid combinations, were equally effective at 160°F against *Enterobacteriaceae* and *E. coli*. The acid mixture worked best at 114°F and 160°F; the mixture and lactic acid alone performed equally well at 68°F.



Microbiologist Gregory Siragusa obtains samples for microbial analysis from a washed carcass while food technologist James Dickson records information about the sample. (K-4284-12)

"There was no magic acid that was effective on all types of bacteria," Anderson says.

Results also indicate that repeated applications of the organic acids, applied with the carcass washer, are more effective than a single application at reducing numbers of pathogens. Much of Dickson's work with sanitation has concentrated on reducing *Salmonella* contamination in beef.

So far, Dickson has succeeded in cutting *Salmonella* contamination in beef by 99.9 percent in laboratory tests. Now he faces the challenge of achieving those same results on the slaughterhouse floor.

Consumers can help minimize risk of ingesting *Salmonella* bacteria by ensuring that beef is cooked properly.

"Heat kills *Salmonella*, so well-cooked meat isn't contaminated," says Jane F. Robens, ARS National Program Leader for food safety. "However, beef is not always well-cooked. That's why the sanitation work is so vital."

While washing and sanitizing are effective in cleaning the beef carcass, scientists at MARC are also trying to eliminate *Salmonella* before slaughter.

Ed K. Daniels, a microbiologist, and Neal E. Woollen, a veterinary medical officer, are searching for a quick, accurate way to detect *Salmonella* bacteria in live cattle.

Currently, the animal's feces is checked for the bacteria. "But we've found through testing that this method really isn't very reliable," Daniels says.

Salmonellosis can be in the tissues but may not appear in the feces. "Hopefully we can use this knowledge to develop a test for identifying salmonellosis in a herd that's a better indicator of the infection than fecal sampling," says Daniels.

He is working on a rapid diagnostic test to detect multiple strains of

*Salmonella* bacteria in tissues, feces, and blood. Once scientists are able to evaluate the presence of the bacterium, they will turn to developing methods to prevent initial infection and possibly rid infected animals of the disease.

"There are several researchers who are developing faster, less expensive, more accurate methods to ensure a safe food supply," notes Robens.

William A. Moats, a chemist at the Beltsville Agricultural Research Center at Beltsville, Maryland, is one of those researchers.

## A good washing removes about 90 percent of the bacteria on a carcass.

Moats has found a better way to detect penicillin residues in beef. Just as a human may take antibiotics or other medications, cattle are also given drugs to rid them of disease. Some of these drugs may stay in an animal's system and be present in the meat.

"What we have developed is a procedure to detect residues of several types of penicillin in beef tissues," says Moats. However, the test must be reviewed by the U.S. Food and Drug Administration and USDA's Food Safety and Inspection Service before it is used in the regulatory arena.

"It's very difficult to separate penicillin from the enormous number of natural compounds, such as vitamins and amino acids, that interfere in the

test," Moats says.

Microbiological tests have been used in the past to detect the drug, but the accuracy of the test was uncertain.

"But we've developed a method using high-performance liquid chromatography (HPLC) that enables us to find minute traces of penicillin in beef," he adds.

In Moats' test, extractions from beef tissue are analyzed using HPLC. A graphic readout from the HPLC equipment indicates that a drug is present.

A duplicate extraction sample is treated with a specific enzyme that destroys penicillin, and the second sample undergoes HPLC analysis. If the subsequent readout does not indicate the presence of a drug, this confirms that the drug pinpointed in the first sample was penicillin.

"This method is very sensitive," says Moats. "We can detect levels of residue much smaller than the Food Safety and Inspection Service's tolerance level of 50 parts per billion."

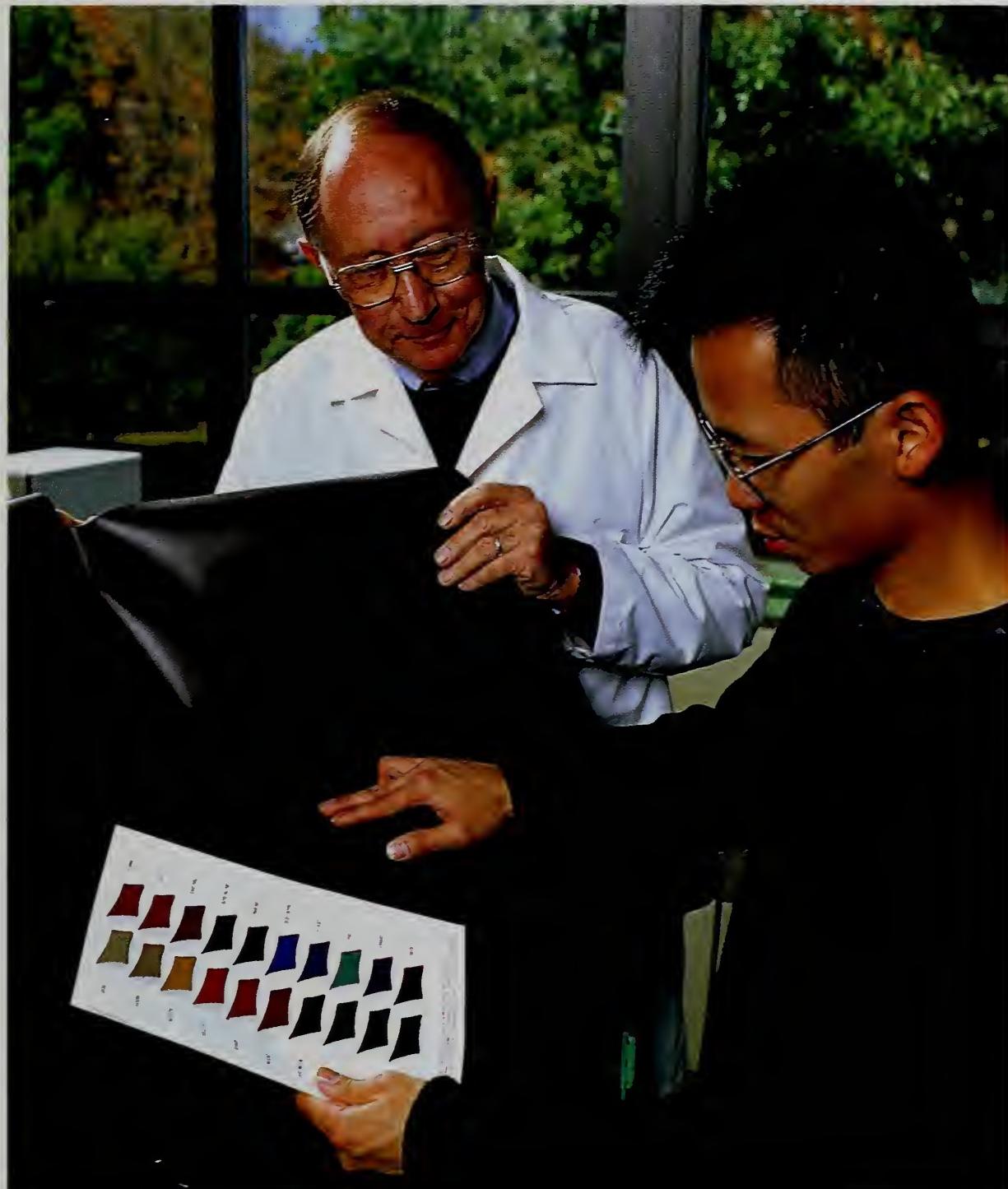
This HPLC procedure detects penicillin V, cloxacillin, and penicillin G, the most common form of the drug. A negative HPLC result provides unequivocal proof that residues of the drugs are not present at or above the sensitivity limits of the method. A positive HPLC result may require further verification.

Moats has also developed HPLC procedures to detect several other animal drugs. However, enzyme systems that will neutralize those drugs are not yet known, so other confirmatory tests must be used.—By Marcie Gerriets, ARS.

To contact scientists mentioned in this article, write or telephone Marcie Gerriets, 1815 North University St., Peoria, IL 61604. Phone (309) 685-4011. ♦

# High-Tech Hides Make Better Leather

SCOTT BAUER



Chemist Frank Scholnick (left) and research associate James Chen examine the results of experimental treatments for leather. (K-4388-1)

**W**hen the first loincloth was donned in prehistoric days, it marked the beginning, albeit simple, of hides and leather technology.

From those rudimentary raiments, an \$8.9 billion per year industry has evolved, with products ranging from automobile upholstery to clothing and, of course, shoes.

Agricultural Research Service scientists are looking for more efficient ways to make leather goods while extending the qualities of

strength and elasticity for several new leather products.

The agency's researchers are also working to replace outdated leather processing techniques with methods that are environmentally friendly.

At the ARS Eastern Regional Research Center in Philadelphia, scientists are studying ways to preserve hides with electron beam irradiation. David G. Bailey, a chemist at the Philadelphia center's Hides, Leather, and Wool Research Unit, says the method could replace salt or brine curing.

Currently, hides are immersed in a saturated salt solution within a few hours after slaughter of the animal. This prevents bacterial growth that breaks down the hide's structure.

Deterioration of the hide seriously hinders the tanner's ability to convert it into leather. The primary function of leather tanning is to stabilize protein fibers so the hide will not readily degrade.

Under proper conditions of cool temperatures and low humidity, brine curing will stabilize the hide from microbial growth for up to 2 years.

Electron beam irradiation uses the same sort of electronic beam used in a television to convert broadcast signals from the atmosphere to a picture on the screen. Accelerating the electrons to very high speeds and subjecting the hide to these electrons destroys the DNA of bacteria lurking there.

"Our method is bringing high technology to what has always been low-technology preservation," he says. "We have some rawhide samples that have not been tanned, but have been irradiated, and they've lasted for 5 years."

"The hide is laid on a moving belt and passes under the beam," Bailey says. "The electron beam can penetrate deeply into the hide."

This type of irradiation is now used to sterilize prepackaged bandages and surgical dressings, Bailey notes.

In addition to its environmental advantages, electron beam preservation is fast as well, allowing the processing of 3,000 to 4,000 hides per day for each machine.

Unfortunately, some physical strength is lost when subjected to this process, but Bailey describes it as "minimal."

Salt curing has several negative side effects related to water pollution and the corrosive nature of concentrated salt solutions. Bailey says about 1 gallon of brine is released for every hide that is brine-cured.

Typically, a fresh hide contains about 64 percent water. Salt curing reduces the moisture content to about 45 percent but adds as much as 14 percent salt to the hide. The tanner removes this by soaking, which creates further salt-solution waste.

SCOTT BAUER



Research associate James Chen studies the stages in which collagen models interact to form larger microfibril units. (K-4387-17)

Bailey has also discovered that temperature has a direct relationship to the hide's salt absorption rate.

But as the temperature of the salt bath drops, so does the rate of salt absorbed by the hide.

"There's no doubt that low temperatures reduce the rate of salt penetration," Bailey says. "What a salt bath can accomplish in June, it can't do as quickly in December."

"In one study, more than 75 percent of the cattle hides cured during the winter months in colder regions of the country had unsatisfactory levels of salt

saturation," Bailey says. "Samples held at the lower temperatures did not achieve a satisfactory cure in 24 hours."

It is important that the proper salt saturation and curing time be coordinated with temperature. If curing time isn't long enough during cold weather,

processors currently have no simple formula for success.

But ARS scientists are working to improve those odds with a computer model that offers a three-dimensional view of collagen—animal skin's fibrous proteins. Collagen is responsible for the strength and toughness of rawhide and the leather made from it.

While the basic shape of collagen is understood, it's unclear how these molecules pack into fine fibers known as fibrils. These molecular reactions determine the strength and flexibility of collagen fibers.

"Each collagen fibril is like a very thin, long string," says James M. Chen. "An enormous number of these are packed together to form skin."

"One thing we need to understand is how these are packed. This will tell us what kind of tanning agent could penetrate and bind."

He says variations in skin packing are similar to building a structure with building blocks. If all of the blocks—collagen molecules—were the same, then normally all structures would be the same. The same is true of animal hides.

But in reality, the collagen molecule is more complex than a building block. It is a large protein molecule with many chemical characteristics; scientists need to know more about its molecular structure. Once Chen, a research chemist at the Philadelphia center develops a computer model of collagen that mirrors collagen in skin, scientists will then be better able to evaluate how different tanning agents affect that structure.

Chen's three-dimensional model has already shown that interactions between collagen molecules are strongly influenced by the number of molecules present at that particular site on the collagen protein. This explains why tanning agents used to modify collagen perform differently at various sites on the protein.

the partially cured hides may look preserved but will spoil more quickly at higher temperatures.

Bailey observed hides cured at 36°F, 50°F, 60°F, and 80°F to reach his conclusions. He found that mechanical tumbling in the bath also increases the rate of salt penetration in the hide.

### Collaring Collagen

When it comes to using tanning agents to manipulate the natural structure of fiber in hides for various leather uses, tanners and leather

"What you may be able to do is design a tanning agent that will modify the skin for strength or softness without damaging the hide," Chen says. "The three-dimensional model allows you to isolate different sites where tanning agents may be reacting."

Chen is also using experimental techniques such as NMR (nuclear magnetic resonance) and circular dichroism to compare information in the computer models with experimental data. His work should be instrumental in designing new tanning agents that give leather characteristics like softness and strength without damaging the fiber.

"It's a well-defined starting point," Chen says of the experiments. "All these studies are matched with the modeling system to see what kind of answers we're getting."

Not only should this research give the leather industry more opportunities to expand the type and quality of leather products. It could also have medical implications. For example, an inheritable disease such as osteogenesis imperfecta, characterized by bone fragility, is due to mutations of fiber-forming collagen. If researchers knew the three-dimensional structure of collagen, they would have a clearer understanding of how these mutations affect it.

### Hides That Don't Measure Up

Paul L. Kronick, a research chemist at the Philadelphia lab, has found a way to reduce the number of poor-quality hides that currently make their way into leather processing. Fifteen percent of these hides are rejected after tanning because they are not strong enough to be made into leather products.

He sorts the hides with laser light-scattering photometry, which evaluates the orientation of fibers in the hide.

Kronick says leather tends to be weaker when the hide's fibers run perpendicular to the hide's surface.

Currently, the only way to detect the direction of hide fibers is by looking at them through a microscope.

Even with the aid of a microscope, Kronick says, it requires "quite a skill" to detect vertical hide fibers. Typically, fibers that crisscross at an angle of about 45 degrees are preferred by leather manufacturers.



Chemist Eleanor Brown uses a nuclear magnetic resonance spectrometer to detect the molecular structure of collagen peptides. (K-4387-2)

"What the laser does is allow the hide buyer to identify the orientation of fibers before a tanner wastes money and time tanning the hide," Kronick says. "It clearly picks them out, reducing post-tanning rejections because of this problem."

Processors sometimes try to control the direction of fibers by stretching the tanned hide, he says. This pulls fibers in a horizontal direction and makes leather stronger, stiffer, and more suitable for products like leather straps.

The laser technique would be useful in computer-controlled manufacturing for indicating how much a particular

piece of hide should be stretched, Kronick says.

To measure the average fiber direction in a piece of hide or leather, Kronick sends a laser beam through a thin slice taken from the sample.

The pattern of light coming through the slice is read electronically and sent to a desktop computer, which calculates the fiber angle. The results can be used to determine which hides to reject, Kronick says.

"The whole thing can be done with desktop computers," he adds. "It ensures that the hide buyer gets what is paid for." —By Bruce Kinzel, ARS.

*David G. Bailey, James M. Chen, and Paul L. Kronick are at the USDA-ARS Eastern Regional Research Center, 600 Mermaid Lane, Philadelphia, PA 19118. Phone (215) 233-6585. ♦*

### Reducing Landfill Waste

ARS scientists have applied for a patent on a bacterial enzyme method for recycling chromium used in leather production.

Chromium sulfate is normally applied to hides to stabilize and preserve them. First used for tanning in the late 1800's, about 90 percent of U.S. tanneries now use the chemical.

A shortage of landfill space is making it increasingly difficult to dispose of the 56,000 metric tons or more per year of chromium waste.

*For details, contact Maryann M. Taylor, Edward J. Diefendorf, or William N. Marmer at the USDA-ARS Hides, Leather, and Wool Research Unit, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. Phone (215) 233-6435.*

## Super Bacteria Boost Yields

Soybeans, the crop that produces more income than any other grown on U.S. farms, yield 5 to 7 percent more when inoculated with a recently patented super bacterium. This increased yield could bring farmers an additional \$507 million income annually.

Soybeans and other legumes have the ability to make their own nitrogen fertilizer through a special symbiotic relationship these plants have with certain soil-dwelling bacteria. Farmers buy these bacteria as legume inoculate and apply them to seed just before planting. The bacteria form nodules on pea, bean, and alfalfa roots, and it is from this new home that the bacteria multiply and manufacture nitrogen.

L. David Kuykendall, ARS microbiologist, Beltsville, Maryland, used classical bacterial genetics to alter a *Bradyrhizobium* species so that it produces more nodules on soybeans than bacteria now commercially available to farmers.

While Kuykendall often uses state-of-the-art biotechnology in his research, this time he selected chemical mutation to create this improved bacterium.

William J. Hunter, ARS microbiologist, Fort Collins, Colorado, studied the physiological and symbiotic characteristics of this new bacterium. In greenhouse studies, he discovered that, under optimum conditions the new bacterium caused soybean plants to produce 56 percent more root nodules and 41 percent more nodule mass than conventional bacteria. Plant nitrogen content increased almost 50 percent and plant weight about 25 percent.

Kuykendall and Hunter have been awarded patent (No. 5,021,076) for their new bacterium. Kuykendall and co-workers in his laboratory had previously conducted research on the physiology and genetics of *Bradyrhizobium* species. They studied how strains already present in field soils compete

with USDA 110, the strain that farmers often use to inoculate seed. [See "The Best Bacteria for Soybean Roots," *Agricultural Research*, October 1989, p.18.]

The researchers say their work should pave the way for scientists to develop improved nitrogen-fixing bacteria for other leguminous plants.—By Dennis Senft, ARS.

*L. David Kuykendall is at the USDA-ARS Soybean and Alfalfa Research Laboratory, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 504-5736. William J. Hunter is at the USDA-ARS Crops Research Laboratory, 1701 Center Ave, Fort Collins, CO 80526. Phone (303) 498-4208. ♦*

SCOTT BAUER



Mature soybeans. (K-4389-2)

## Disease-Free Peas

Green peas for freezing and canning grow in many places throughout the United States—Washington, Wisconsin, even New Jersey. But no matter where they are, most peas are susceptible to a trio of soilborne fungi that can ruin a farmer's crop. And no currently registered fungicides can stop the diseases.

But new pea varieties with built-in resistance may be on the way soon. Plant pathologist John M. Kraft, who is

with the ARS Vegetable and Forage Crops Research Unit in Prosser, Washington, has three new pea breeding lines that show good resistance to all three ailments—common root rot, *Fusarium* root rot, and pea wilt.

Seed companies can use the new lines for crossing with their own, specialized varieties, hopefully retaining the resistance traits.

Before the release of Kraft's new peas, with three more lines from the University of Wisconsin, Madison, there were no pea plants that possessed the qualities important for commercial growers, like high yields and good flavor, but that could also resist soil fungi.

Common root rot, caused by *Aphanomyces euteiches*, is especially bad in wet, heavy soils. The fungus has become a serious problem in parts of Washington and, in past years, has devastated pea plantings in New Zealand.

The ailment makes pea roots turn brown and slimy, yielding stunted, yellow plants with only a few pods. Similar symptoms appear with a *Fusarium* root rot infection.

Pea wilt causes the plant's leaves to yellow, dry, and curl up. It often kills plants even before they bloom.

Peas are tricky to grow; they're very sensitive to environmental stresses like excess heat, cold, moisture, and soil compaction. And because peas have such a short growing season—only 60 days from seed to harvest—the crop doesn't have time to recover from diseases or other stresses. That's why disease resistance is so important, Kraft says.

Some of the new peas' wild ancestors came originally from Ethiopia, India, and Pakistan via the USDA's Plant Introduction Station in Pullman, Washington.—By Julie Corliss, ARS.

*John Kraft is with the USDA-ARS Vegetable and Forage Crops Production Research Unit, Irrigated Agriculture & Extension Center, Rte. 2, Box 2958-A, Prosser, WA 99350-9687. Phone (509) 786-3454. ♦*

# AGNOTES

## Enzyme Gets the Guava Juice Out

Juice from freshly picked guavas adds a light, clean taste to fruit beverages and carbonated drinks.

Food processors can extract a clear juice from guavas using natural enzymes, says ARS food technologist Harvey T. Chan at Hilo, Hawaii.

Chan and co-researchers reported recently that enzymes they've tested during the past few years yield more juice, in a shorter time, than those Chan tried more than a decade ago. What's more, today's guava juice is clearer and thinner, making it less likely to clog filters or narrow tubing used in producing sodas, sparkling water, and fruit juice blends. Blockages caused by bulky pulps, in contrast, can sometimes wreak havoc in bottling plants.

The thinner, clearer, amber-colored juice is also easier to make into a more highly concentrated product; that is, one that has very little water in it. "Because of the reduction in volume and weight," explains Chan, "it costs less to transport and store a concentrate than a full-strength juice. Later, at the bottling plant, you can add back as much water as you want."

Guava juice is high in vitamin C. It's also a good natural source of citric acid. That's an advantage for makers of all-natural beverages who need something besides synthetic citric acid to get the perfect balance of sweet and tart flavors in their product.

The hardworking enzymes Chan and colleagues used hasten the separation of juice from the thick pulp. The enzymes, called pectinases, speed the natural breakdown of pectin, a component of fruit cell walls.

In nature, fruits release their own pectinases as they ripen and soften. The scientists opted for pectinases derived from a fungus, *Aspergillus niger*.

Raised in indoor vats, *A. niger* is a prolific producer of the pectinases that are widely used to make wines or extract clear juice from apples, pears, pineapple, and about a dozen other fruits.

Chan worked with food technologists Aurora S. Hodgson and Catherine G. Cavaletto at the University of Hawaii and Conrad O. Perera at New Zealand's Department of Scientific and Industrial Research. They found that the enzymes work well on any kind of purée—fresh, thawed, or shelf-stable aseptic packs (the kind used for boxed juices).

Pectinases take about 2 hours to break down the pectins in guava purée that's heated to 122°F.

Although some of the nation's largest beverage companies have inquired about the clarified guava juice, they have yet to add it to their products, Chan says. But he and co-workers are still confident of the potential of today's clearer and thinner guava juice.

"When you list guava on a product label," Chan notes, "you're adding the appeal of both an exotic tropical fruit and an all-natural ingredient." —By Marcia Wood, ARS.

*Harvey T. Chan, Jr., is with the USDA-ARS Tropical Fruit and Vegetable Research Laboratory, P.O. Box 4459, Hilo, HI 96720. Phone (808) 959-9138.* ♦

## Watching Cholesterol—in Worms and Oysters

Fewer pesky crop-attacking nematodes and more tasty oysters: A boost toward both goals may come from a new test to pinpoint sterols.

Nematodes cost U.S. farmers \$7 billion a year in pesticides and damage to corn, soybeans, and other crops. But the test could speed efforts to find safer alternatives to current pesticides against nematodes, says zoologist David J. Chitwood, who devised the test.

The test more quickly and accurately pinpoints cholesterol and other sterols needed by nematodes—worms that live in soil and prey on roots. Needed by all plants and animals, sterols form chemical building blocks for fats and hormones.

"Nematodes convert sterols from plants into cholesterol and other forms that they need to grow on, make hormones, and reproduce," Chitwood says. "Safe compounds to short-circuit this conversion would be a boon to farmers."

Chitwood's test, which was developed at the ARS Nematology Laboratory in Beltsville, Maryland, is a modification of a method called reversed-phase high-pressure liquid chromatography. With fewer steps than present techniques, the new one takes as little as 30 minutes.

He used it to identify 28 sterols in the corn root lesion nematode, including 9 found for the first time in any nematode.

That's a good sign compounds could be developed to thwart this worm's sterol pathways without harming anything else in the environment.

It's not underground pests but underwater treats that captivate a University of Maryland botanist. Glenn W. Patterson has adapted Chitwood's test to his studies of oysters. Patterson's objective is to learn which algae supply the best sources of sterols and other nutrients for oysters in the Chesapeake Bay.

While the mollusks get some sterols from green algae, they may get more from brownish to yellowish algae, called diatoms.

"In some studies," he says, "big, healthy, fast-growing oysters had higher sterol levels than slow-growing oysters. We want to learn which sterols are most important in oysters and which algae—green ones or diatoms—best supply them. Then we'll have a scientific basis for knowing what improvements in the bay's water quality would best promote oyster growth." —By Jim De Quattro, ARS.

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